Effect of Biopriming on Seed Quality Parameters of Cotton

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Swami Ramanand Teerth Marathwada University, Nanded (M.S)

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Submitted by

Swami PratimaMallikarjun

(M.Sc. Botany)

Under the Guidance of

Dr.S.V.Chate

P.G. Dept. of Botany& Research Centre

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Research Scholar: Swami Pratima Mallikarjun

Research Supervisor: Dr.S.V.Chate

Research Centre: P.G. Dept. of Botany, Shivaji Mahavidyalaya Udgir, Dist-Latur.

Abstract:

Cotton is the world's most important oilseed crop and the chief crop for producing fiber. Warming temperatures and decreasing water supplies, both of which have an impact on soil salinity, pose a hazard to cotton plants output. Cotton is extremely vulnerable to heat and salinity stressors throughout the germination, emergence, and young seedling stages. The critical stages during the growth of crops are the uniform seed germination, early seedling growth, and uniform plant stand. Low crop yield is attributed to uneven seed germination and seedling growth. Therefore, the quality of seed can be improved through priming in addition to the field management techniques for better seed germination.Many seed invigoration treatments are employed in a range of field crops, including cereals, pulses, vegetables and others to improve seedling establishment under natural and stressful conditions.Some of the treatments used to invigorate seeds including seed priming methods such as hydro-priming, osmo-priming, nutrient priming, chemical priming, bio-priming and advanced methods (nano-priming and priming with physical agents) being useful for enhancing the seed germination, seedling vigour and to overcome abiotic stress. The primed seeds show faster and uniform seed germination as compared to unprimed seeds. Moreover, to these advantages, of all priming methods biopriming method gives an extra advantage of biotic stress management and thus gains special attention. Range of bacterial or fungal bio agents, Mycorrhiza and Cyanobacteria, whether they are biofertilizer or biopesticide, may be useful as biopriming agents.The development of seed priming treatments based on botanicals has been one approach of seed enhancement. Seed priming is useful in almost all the crops over the globe and is an eco-friendly substitute to chemical fungicides.This method must be applied to all agricultural crops. However, priming is strongly affected by various factors such as temperature, aeration, light, priming duration, and seed characteristics. To fully understand the seed quality issue, a complete assessment of current technology and its consequences for growth and output is required. As seed priming has been proven to be beneficial, it must be standardized across all crop species together with cotton.

Key Words-: Priming, Germination, Emergence, Vigour, Storage, Cotton Seeds, Biopriming.

Introduction

One of the most important and commercially significant crops in the world is cotton, also known as "white gold". It has a tremendous impact on economies and global agriculture in addition to textiles. Research on cotton is essential for understanding the complexity of this adaptable crop, providing answers to urgent problems, and influencing the direction of agriculture. It is a soft fibre shrub, native to tropical and sub-tropical regions around the world including America, India, and Africa (Idem, 1999).

Cultivated cotton belongs to the Genus *Gossypium*, in the Family Malvaceae, and the commercial varieties belong to four species. Among the four domesticated species two are diploid (*Gossypium arboreum*and *G. herbaceum*) and other two tetraploid (*Gossypium hirsutum* and*G.barbadense*)[1]. Another unique characteristic of cotton is its seed. Both maternal and filial tissues have economic value, since part of the seed coat epidermal cells grow into cellulose-rich fibers while the embryo cells produce protein and oils [2]. Owing to this, cotton is one of the most important crops in the world, grown predominantly for the fiber as the primary natural source of the world's textile industry, and its seed is extensively used for feedstock and oil for human consumption [3,4].

The significant fluctuations in world cotton production and consumption and decreasing yields require world cotton science to pursue new research directions and develop innovations to substantially increase and stabilize cotton production worldwide [5, 6].Due to global climate change, increased heat and drought stress and biosecurity issues, it is demanded to improve drought, salt and heat tolerance traits as well as to increase the resistance characteristics of cotton cultivars to better respond to existing and emerging bacterial, fungal, and insect pest infestations.[6, 7].

As seed is a biological entity, degradation is unavoidable after harvest. The cotton seeds deteriorate at a rate sufficiently rapid to make them a poor planting material soon after the attainment of physiological maturity.Consequences of poor-quality seeds are poor germination, slow emergence, weak growth, and inadequate field stand etc., all orienting towards reduced yield. To overcome germination and vigour constraints, by uniform crop stands, earlier crop development, and better yields seed treatments through physical, chemical, and biological means have been proposed.[8].

Pre sowing seed treatment (Seed invigoration) refers to beneficial treatments applied to seeds after harvest but before sowing that boost germination or seedling growth or promote the delivery of seeds and other elements required at the time of sowing. Seed enhancement is a range of treatments of seeds that improves their performance after harvesting and conditioned, but before they are sown. Seed enhancement include priming, hardening, pregermination, pelleting, encrusting, film coating etc, but excludes treatments for control of seed borne pathogens (Black et al. 2006).[9].Priming is one of the most important physiological methods which improves the seed performance and provides faster and synchronized germination. The primed seeds give earlier, more uniform and sometimes better germination and seedling establishment and growth (Bradford, 1986).[10]Seed priming is useful in almost all the crops over the globe and is an eco-friendly substitute to chemical fungicides. This method must be applied to all agricultural crops. Laboratory experiments demonstrated that hydropriming increased the speed of germination in cotton, which is grown commercially in many semiarid regions worldwide. In these areas, where precipitations are sparse and irregular, temperature and water stress are frequent factors inhibiting cultivation.[11]

The development of seed priming treatments based on botanicals (leaf extracts) has been one approach of seed enhancement. Since seed priming has been proven to be beneficial, it must be standardized across all crop species. However, priming is strongly affected by various factors such as temperature, aeration, light, priming duration, and seed characteristics. To fully

understand the seed quality issue, a complete assessment of current technology and its consequences for growth and output is required.

Review of Literature and Development in the subject (Previous work done in the relevant area):

Heydecker,(1973), pioneered the idea of seed priming for seed germination[12]. Seed priming is a technique to stimulate rapid germination and homogenous seedling emergence by hydrating the seeds before sowing. Priming allows some of the metabolic processes necessary for germination to occur before germination take place. In priming, seed are soaked in different solution with high osmotic potential. This prevents the seeds from absorbing enough water for radicle protrusion, thus suspending the seeds in the lag phase. Seed priming has been commonly used to reduce the time between seed sowing and seedling emergence and to synchronise emergence (Parera and Cantliffe, 1994).[13].

Seed priming is a regulated hydration process that is commonly used to improve seed output by improving germination characteristics such as rate and uniformity, as well as lowering seed sensitivity to external factors. Seedlings from primed seed grow faster, grow more aggressively, and perform better in adverse conditions (Desai et al., 1997).[14].

Seeds are soaked in water and dried before sowing in hydropriming (Soon et al., 2000) [15]. Soaking can be done with or without aeration by submerging seeds in water (Thornton and Powell, 1992) [16]. Nondormant seeds would germinate quickly if enough water, oxygen, and the right temperature were available. It is an environmentally friendly technique since no chemicals are used during the process. One potential drawback of this method is that seed hydration is often inconsistent, resulting in nonuniform germination (Pill and Necker, 2001) [17]. The time of hydropriming is critical for seed invigoration.

Seed priming have important role in increasing the yield of different crops in relation to enhance 37, 40, 70, 22, 31, 56, 50 and 20.6 percentage in wheat, barley, upland rice, maize, sorghum, pearl millet, and chick pea respectively (Harris et al., 2005).[18].

Priming has proved that crop seeds primed with water germinated early, root and shoot development started rapidly, grew more vigorously and seedling length was also significantly greater than nonprimed seeds. It could also improve the performance of crop by alleviating the effect of salts under saline soil conditions (Mohammadi et al., 2008).[19].

Seed priming have various techniques for improving the performance of growth, emergence and yield of the crop. There are some techniques used like hydro-priming, osmo-priming, bio-priming and hormonal priming. The rate of seed germination and seedling growth can be influenced by various concentrations of growth regulators i.e., GA3 (Saeedipour 2013).[20].

Yao et al. (2006) assessed the effectiveness of FZB 24® Bacillus subtilis (ABiTEP GmbH Berlin) as a biofertilizer for increasing the cotton yield in comparison with the conventional fertilizer containing NPK. The FZB 24 Bacillus subtilis, helps to improve plant growth and

yield based on increasing the capacity of roots to mobilize and take up nutrients and substances for overall reproductive plant fitness.[21].

There are some research papers on cotton seed priming, but they may be less than other crops because cotton is a relatively drought-tolerant crop that can germinate and emerge under a wide range of soil moisture and temperature conditions. However, cotton seed priming can still improve germination, emergence, yield, and water use efficiency under stress conditions such as salinity, high temperature, and low temperature. Some of the seed priming agents that have been tested for cotton are hydropriming, gibberellic acid, salicylic acid, potassium nitrate, calcium chloride, and brassinosteroids etc.

Gawade (2009) studied the efficacy of bioagents i.e. talc powder formulations of Pseudomonas fluorescens (0.6%), Trichoderma viride (0.6%), Pseudomonas fluorescens + Trichoderma viride (0.6%) each and Thiram + carbendazim (0.2%) on seed mycoflora, seed germination, seedling vigour index and field emergence in desi cotton (Gossypium arboreum L.). The seed treatment of P. fluorescens + T. viride was effective in reducing seed mycoflora i.e. Fusarium oxysporum, Fusarium moniliforme, Aspergillus niger, Aspergillus flams and Alternaria macrospora by 87, 100, 79, 76 and 100 percent respectively over untreated control. The seed germination, seedling vigour index, and field emergence of desi cotton was increased by 19.25, 21.33, and 11.27 percent respectively.[22]

Naraghi et al. (2012) conducted a study on two major crops, cotton, and potato to evaluate their growth promotion by the antagonistic fungus Talaromyces flavus against the wilt diseases on these plants. The isolate, TF-Co-M-23 was the most effective isolate for cotton plants which increased root length, plant height, plant fresh weight, and plant dry weight by 1.80, 2.26, 1.23, and 1.19-fold respectively.[23]

Bacillus spp. have proven to be suitable for developing stable and efficient biological products because of their ability to produce heat-resistant endospores (Errington, 2003; Yanez-Mendizabal et al., 2012) which survive the stresses of commercial seed treatment better than nonspore-forming species such as *Pseudomonas*spp. [24].

Bacillus subtilis was used extensively as a cottonseed treatment in the USA (Brannen and Kenney, 1997) and is currently marketed as Kodiak (Bayer Crop Science, 2014).[25].

The inoculums can be applied as water-based slurry with other registered seed treatment insecticides and fungicides through standard seed treatment equipment. Khiyami et al. (2014) studied the management of cotton seedling disease complex using different Bacillus strains under greenhouse conditions. The Bacillus circulans and B. coagulans were the most effective strains in controlling the cotton seedling disease.[26].

Faria et al. (2003) studied the efficiency of the treatments of cotton seeds with the fungicides and comparing them with T.harzianum, in the seed germination and vigour in the promotion of seedling growth. Seeds treated with T.harzianum, carbendazin+thiram and carboxin+thiram

showed higher germination and emergence and the first two also resulted in more vigorous seedlings.[27].

The effect of hydropriming and osmopriming in mannitol on cotton seed germination during their storage was evaluated by Toselli and Casenave (2014). In the case of hydro priming, the enhancement produced by these priming treatments remained at least for 6 months and 12 months for osmopriming in mannitol. The osmopriming was more effective in increasing the velocity of germination and vigor index. Priming enhanced the behavior in young and older seed lots, however, more effective on the younger seeds.[28].

Murungu et al., (2013) carried out a pot experiment with cotton at Zimbabwe. They observed in the laboratory that, priming improved emergence and early growth of cotton in dry soils. The increase of emergence from 75 to 99 % at soil matric potentials and had longer roots than non-primed seedling at all initial matric potentials. There was no direct effect of priming on growth, time to flowering, and maturity or yield of plants. Instead, the advantages of priming appeared to be indirect effects of improvements in crop stand and the advancement of germination and emergence.[29].

K. Ragadevi et al., (2021) obtained experimental and showed that cotton seeds treated withSingle and combined inoculation of PGPR strain in cotton seeds considerably improved the germination efficiency and plant growth during the early growth stage. However, seeds inoculated with individual strain of Azospirillum sp7 and PPFM TNAU1 outperforms the combined inoculation of PGPR strains. These results indicate that PGPR strain inoculation has a positive stimulant effect on germination efficiency and plant growth promotion in the cotton crop. It is concluded that the investigated beneficial microbes can be employed to increase the physiological potential of cotton to achieve higher yield.[30].

Recently Chakma, S.P et.al (2021) explicated that seed priming can enhance the germination, yield, and water-deficit stress tolerance of cotton under different conditions.[31].

Awan Z.A. & et al. (2022), stated that seed priming is an efficient and cost-effective technique that plays a vital role in better crop establishment consequently increasing germination rate, plant growth attributes and productivity of the cotton crop. [32].

Plants raised from KNO3- and GB-primed seeds outperformed all other treatments and caused a significant increase in germination-related traits and other evaluated parameters. Priming cotton seeds with KNO_3 at 5 g L^{-1} or GB at 100 mg L^{-1} can be recommended as a promising technique for growing cotton under water-scarce environments. Some factors that can affect the effectiveness of seed priming are temperature regimes, light sources, energy densities, and priming agents such as salicylic acid, silicon, potassium nitrate, proline, and glycine betaine. The deleterious effects of drought stress on cotton (*Gossypium hirsutum* L.) could be mitigated through seed priming.[33].

Elias, S. G., & et al. (2022), stated that Biopriming is a technique that involves applying plant growth promoting rhizobacteria (PGPR) or other natural compounds to seeds before sowing to enhance their germination, establishment, and tolerance to stress.[34]

Brown and Saa, 2015. Plant based biostimulants, apart from inducing stress tolerance, are also effective in regulating a number of plants physiological processes; thereby improving plant growth and yield.[35].

Elzaawely et al., 2018.Among various plant based biostimulants, PEs are economical and easy to prepare. Several studies have reported their beneficial effects on plants growth and yield. For instances, an increase in the growth and hormonal profile was observed in eggplant and snap bean when aqueous garlic extracts were applied.[36].

Ali Ahmad & et al. (2022), stated that Plant extracts (PEs) are one type of natural compound that can act as biopriming agents.Whole plants or parts of plants, i.e., roots, leaves, flowers, bark, seeds, pollens, etc. can be used to prepare PEs through aqueous or organic-solvent extraction techniques. PEs are multicomponent organic mixtures, containing vitamins, carotenoids, amino acids, phytohormones, mineral nutrients, phenolics, and antioxidants, etc., which facilitate stress signaling, genes regulation, redox metabolism, and synthesis of various proteins and metabolites. Some examples of PEs that have been shown to improve plant growth and yield under salt stress are moringa, neem, garlic, and ginger.The degree of impact of PEs depends on various factors like plant species, age of plant, application method, etc.[37].

Society Application:

[International Status/National Status]

Many nations, including India, Pakistan, China, and Australia, have adopted the seed priming approach, and more than a thousand trials have been carried out to assess the effectiveness of priming in different crops. China, India, and the United States are currently the three major cotton-planting countries worldwide [38]. Cotton hybrids were initially researched in the United States but first applied on a large scale in India and then in China [39].

India has the largest area under cotton cultivation in the world (9.1 million ha.) and grows all four cultivated species namely, G. hirsutum, G. barbadense, G. herbaceum and G. arboreum on commercial scale. The major cotton growing states are Punjab, Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, A.P., Tamil Nadu and Karnataka. However, the productivity of cotton in India is low due to its rainfed cultivation in major areas (66%) and inadequate use of quality inputs. India is the pioneer country for commercial cultivation of cotton hybrids which covers more than 50% of the cotton area. Hybrid cotton seeds have some advantages over conventional ones, such as higher yield, better fiber quality, and stress resistance. However, they also have some challenges, such as higher production costs, lower seed purity, and environmental risks. (V.Santhyet.al)[40] .

Among the different seed treatments, biological seed treatments are expected to be one of the fastest-growing seed treatment sectors shortly due to its eco-friendliness. Lack of awareness of seed treatments at farmer's level is one of the limiting factors and hence, efforts should be made at farmer's level to adopt the technology. Priming allows some of the metabolic processes necessary for germination to occur before germination take place.

Hybrid cotton seeds have some advantages over conventional ones, such as higher yield, better fiber quality, and stress resistance. However, they also have some challenges, such as higher production costs, lower seed purity, and environmental risks.[41].New technical developments, such as the impact of pre-sowing seed treatments on germination and seedling growth parameters, provide new understandings of how to comprehend and create improved crop management strategies.

Current production of cotton fiber is not sufficient to meet the increasing demand of world population which arises due to many limiting factors, i.e., frequent droughts, soil degradation, salinity, and alkalinity. To date, many farming practices were employed to increase cotton production, as a consequence, toxic impacts were implied on water and soil resources. In addition, a major part of the chemical fertilizers applied to the crops remain in the soil as insoluble inorganic compounds and promotes toxicity to the soil. Lately, efforts have been focused on minimizing the usage of chemical fertilizers in order to optimize production cost and protect the environment against pollution without compromising the seed cotton yield.

Cotton biopriming technique involves imbibing cotton seeds with beneficial bacteria and Plant extracts (PEs) that can enhance germination, growth and stress tolerance. Among various plant based biostimulants, PEs are economical and easy to prepare. Several studies have reported their beneficial effects on plants growth and yield. Use of Plant Extracts to combat plant stress there by increasing growth parameters is an efficient, economical, and sustainable approach. Seed priming on the farm is a quick, low-cost, and low-risk method for encouraging seedling establishment as well as vigorous and faster seedling growth. There are less research papers on cotton biopriming because it is a relatively new and emerging field of study that requires more investigation and experimentation.Hence Plant growth regulating impact through biopriming is asignificant topic for the research by exploiting novel combinations of seed priming agents as bioinoculant.Therefore, present study has been undertaken to find out the effect of biopriming on the germination and emergence of cotton hybrid cultivars.

Significance of the study:

At present, bio-priming of cotton seeds, development of suitable microbial and plant extract-based bio-priming agents and their application to facilitate penetration among farming community are very essential. Therefore, efficacy and potential bioagents and novel botanicals for the development of bio-priming agents, development of formulation and production of bio-priming agents and their suitable delivery mode, laboratory and field trials and generation of bio efficacy data on different crops, popularisation of technologies among the farmers and registration and commercial production by the agro-industries are needs of the hour.

Further priming has proved beyond doubt, but still a large number of microorganisms and plant based priming agents remain underutilised for this purpose with the capacity to alleviate varied biotic/abiotic stresses. These bio-inoculants in association with plant have much better stimulatory effect on managing pest/diseases, plant growth and nutrient uptake in stressful environmental conditions. Thus, integrating these bioinoculants to seed through bio-priming can successfully alleviate biotic as well as abiotic stress conditions in agricultural system thereby improving the seed quality and yield in limiting environments.

This Research work highlights the priming mechanism and the bio priming as a tool for superficial seed germination and crop stand. Experiments with reference to the importance of Seed priming toward seed germination, vigour and seedling growth will be conducted with reference to selected cotton hybrid and its results will be interpreted at the end of the research work.

Aims and Objective of Research

The purpose of this study is to evaluate the effects of various seed priming materials on cotton seeds in laboratory and pot experiments in order to improve cotton plant germination, emergence and growth, by hydropriming and using beneficial microorganisms or botanicals to treat the seeds before sowing with the following objectives.

I. To find out suitable seed priming treatment for assured Seed Germination and Emergence.
II. Effect of seed priming treatments on seed quality parameters.
IV. To compare the effectiveness of these priming materials.
V. Effect of biopriming treatments on storability cotton seeds.

Proposed work plan/ Formulation and Structure of Study:

The present investigation is planned to work on “Effects of Biopriming on Seed Quality Parameters of Cotton” during theExperimental period 2023-24, 2024-25 and 2025-26 at P.G. Dept. of Botany and Research Center, Shivaji Mahavidyalaya Udgir, Dist-Latur. (Affiliated to Swami Ramanand Teerth Marathwada University, Nanded, Maharashtra).

1. Seed collection and preparation

The experiments will be conducted with the seeds of recently released genetically pure cotton hybrid variety CICR- H Bt Cotton 62 (Namami Bt / CICR 19-32 Bt) released in 2022. Seeds will be Procured from Cotton Research Center and kept at room temperature for further investigation followed by acquisition of Bio inoculants used for seed treatment. (Source-Information Compiled by Dr. S Manickam, Dr. M. Sabesh Source: Release Proposals; Gazette Notifications updated: 17:08:2023).

2. Seed priming treatments

Prior to seed germination study, the seeds will be subjected to eight major pretreatments viz.,

Detail of Treatments	
T1	Control (without priming)
T2	Hydro-priming (priming with water)
T3	Biopriming with Rhizobacterium
T4	Biopriming with Fungal Bioagent
T5	Biopriming with Cyanobacteria
T6	Biopriming with leaf extract of *Cassia tora*
T7	Biopriming with leaf extract of *Tinospora cordifolia*
T8	Biopriming with leaf extract of *Achyranthus aspera*
(T1) A control set of experiment (without any pretreatments) is used to compare the result with the treated seeds and for each treatment, 100 seeds will be used, replicated five times. (T1) Hydropriming-Seeds we be soaked in tap water inside a 100 ml beaker for 24 hours at room temperature (28±2 °C) and then and air dried to original moisture content; (T3) seeds were soaked with Rhizobacterium inoculum and kept for 12 and 24 hours finally air dried; Similar procedure will be followed for T4 to T8.[Required number of Treated seeds will be kept in laboratory condition and untreated seeds (control) will also maintained for additional experiments].	

3. Germination experiments Preparation

Treated seeds were sown in two types of media i.e.,top of paper (TOP)and soil. Whatman No 1 filter paper will be used for TOP media.For soil media, properly sterilizedblack soil free from impurities and toxic chemicals will be placed in medium sized pot. sterilization will be carried out by oven drying the soil. [42]

Three replicates with 20 seeds for every treatment will be used fortop of paper (TOP); totalling 960 seeds (20 seeds x 3 replicates x 16sub treatments with two concentrationseach seed priming agent). Two replicates with 5 seeds for every treatment will be used for pot experiment; totalling 160 seeds (5 seeds x 2 replicates x 16 sub treatments with two concentrations of each inoculant).Total 1120 number of seeds required for single experiment. Two sets of 1120 seeds will be maintained in storage after priming has been completed. Treated seeds will be kept in laboratory condition and untreated seeds (control) will be refrigerated to preserve its initial quality to carry out storability experiments.[43].

Eight major treatments having subdivision of varying treatment concentration and time (for Hydropriming), along with one control, represents the 16 sub-treatments. Both the substrata will kept moisten by adding distilled water whenever needed throughout the duration of the experiments. The experiment will be laid out in a completely randomized block design with two factors (seed treatment and germination characters). After pretreatments Petri dishes were kept in a growth chamber at a constant temperature (30±2°C) and 12/12 hr light and darkness (Except for hydropriming 12 hr and 24 hr) and potted seeds will be maintained under normal laboratory conditions. Germination will be monitored daily and recorded. Seeds will be

considered germinated when healthy white radicle was seen emerged through the integument (ISTA, 1976).

4. Seedling Emergence and growth Parameter Study

The initial growth parameters are estimated using ISTA (1999) guidelines. The percent germination (GP), mean germination time (MGT), germination energy (GE), germination index (GI) and seedling vigour (SV) was calculated as shown the table[44]:

	Parameters	Calculation
1	Germination percentage (GP)	Germination percentage (GP): the number of germinated seeds as a percentage of the total number of the tested seeds (Tanaka-Oda et al., 2009). GP = (germinated seeds/total tested seeds) x 100 %
2	Mean germination time (MGT),	Mean germination time was estimated by formula given by Scott et al. (1984) as; (MGT days): = $\Sigma T_i N_i$ / S Where T_i is the number of days from the beginning of the experiment, N_i the number of seeds germinated per day and S is the total number of seeds germinated.
3	Germination index (GI)	GI = $(G_1/1) + (G_2/2) + \ldots\ldots\ldots + (G_x / x)$ Where G is the germination day 1, 2…, and x represents the corresponding day of germination (Esechie, 1994).
4	Seedling vigour Index I [SVI-I]	% germination X Seedling Length(cm) SV = Sh x GP, Where Sh is the seedling height and GP is the Germination Percentage (ISTA, 1985).
5	Seedling vigour Index II [SVI-II]	% germination X Seedling Dry weight(g)
Shoot length and Root length will be measured and mean value can be calculated in cm. After 45 days dry weight of the seedling will be estimated by oven drying at 60˚C for 48 hours.		

Year-wise Plan of work and targets to be achieved

Genetically pure seeds of cotton Hybrid variety CICR- H Bt Cotton 62 (Namami Bt / CICR 19-32 Bt) will be used for study and biopriming agents will be will be procured and kept ready for further experimentations with desired concentrations as described by earlier workers. Required number of Treated seeds will be kept in laboratory condition and untreated seeds (control) will also maintain for storability experiments.

First year (2023-2024):

Optimization Experiment-Seeds treated and planted immediately after priming (time 0). Experiment will be carried out to find out effect of priming materials and their concentrations for optimizing duration of hydropriming and concentrations of biopriming agents for improved seed germination in Cotton.

Second year (2024-2025): -

To determining if the effect of the treatments maintained during the time/storage, the primed seeds newly planted will be evaluated 6 and 12 months after priming has been completed.

Third year (2025-2026): -

Statistical analysis using established procedures, calculations, tables, graph plotting, photography and other paper work will be completed in due course.

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